Name _____ Class _____ Date _____

CHAPTER 2 Earth as a System

SECTION 2

Energy in the Earth System

KEY IDEAS

As you read this section, keep these questions in mind:

- What is the difference between an open system and a closed system?
- What are the characteristics of Earth's four spheres?
- What are the two main sources of energy in the Earth system?
- What are four cycles of matter on Earth?

What Is a System?

Earth scientists often say that Earth is a system. A **system** is a group of related objects or processes that work together to form a whole. Systems can be as small as an atom or as large as the whole universe.

The Earth system is made up of many smaller systems. Each smaller system is made up of even smaller systems. For example, one part of the Earth system is the ocean system. One part of the ocean system is coral reefs. Coral reefs are systems made up of even smaller systems, such as rocks and living things.

The parts of a system interact, or affect one another. Systems can also interact with other systems. Systems can interact by exchanging matter or energy. *Matter* is anything that has mass and takes up space. *Energy* is the ability to do work. Heat, light, and vibrations are examples of energy.

OPEN SYSTEMS

There are two main kinds of systems on Earth: open systems and closed systems. An *open system* is a system that exchanges both matter and energy with the surroundings. The jar shown below is an open system.

This jar of tea is an open system. Both matter and energy can enter and leave the system.

READING TOOLBOX

Outline Use the boldface headings to make an outline of the section. As you read, fill in the outline with the important ideas from the section.

Talk About It

Apply Concepts Think of five examples of systems you see every day. Share your ideas with a partner. Explain why you think each example is a system.

LOOKING CLOSER

1. Explain Why is the jar of tea in the picture considered an open system?

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Critical Thinking

2. Compare How is a closed system different from an open system?

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CLOSED SYSTEMS

A closed system is a system that exchanges energy but not matter with the surroundings. The sealed jar in the figure below is an example of a closed system. Energy can move into and out of the jar. Because the jar is sealed, no matter can enter or leave the system.

This jar of tea is a closed system. Energy can enter and leave, but matter cannot.

Earth is almost a closed system. Energy enters the Earth system in the form of sunlight. Energy leaves the system in the form of heat. Only tiny amounts of matter enter and leave the system. Therefore, scientists often model Earth as a closed system.

What Are Earth's Four Spheres?

The Earth system is made up of four "spheres." These spheres are not large round objects. They are the different areas where all of Earth's matter is found. The four spheres are the atmosphere, the hydrosphere, the geosphere, and the biosphere. ☑

READING CHECK

3. Identify What are Earth's four spheres?

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THE ATMOSPHERE

The **atmosphere** is the layer of gases that surrounds Earth. The air we breathe is part of the atmosphere. The atmosphere also protects Earth from much of the sun's harmful radiation. About 78% of Earth's atmosphere is nitrogen gas. About 21% is oxygen gas. The rest is made up of other gases, such as argon and carbon dioxide.

Critical Thinking

4. Infer What percentage of Earth's water is salty?

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THE HYDROSPHERE

All the water on Earth makes up the **hydrosphere**. Almost all the water in the hydrosphere is salty. Only 3% is fresh water. Fresh water is found in streams, lakes, and rivers. It is also frozen in glaciers and the polar ice sheets and is found underground in soil and bedrock.

THE GEOSPHERE

The **geosphere** is all the rock and soil on the continents and on the ocean floor. The geosphere also includes the solid and liquid rock and metal inside Earth. Some natural processes, such as volcanic eruptions, bring matter from Earth's interior to its surface. Other natural processes move surface matter into Earth's interior.

THE BIOSPHERE

The **biosphere** is made up of all Earth's living things. Organic matter from dead organisms is also part of the biosphere. Once this organic matter has decomposed, it becomes part of the other three spheres. The biosphere extends from within Earth's crust to a few kilometers above Earth's surface.

This photo shows examples of all four of Earth's spheres.

EXCHANGE OF MATTER AND ENERGY

You can think of Earth's four spheres as huge storehouses. They store matter and energy. The matter and energy can move from one sphere to another, or within a sphere. However, matter and energy can only change forms. They cannot be created out of nothing or completely destroyed.

Certain processes move matter and energy from place to place in predictable ways. These processes include chemical reactions, radioactive decay, and the growth and decay of living things.

Talk About It

Learn Word Roots Use a dictionary to look up the meanings of the word roots *hydro-, geo-,* and *bio-.* With a partner, discuss how these word roots are related to the meanings of the words *hydrosphere, geosphere,* and *biosphere.*

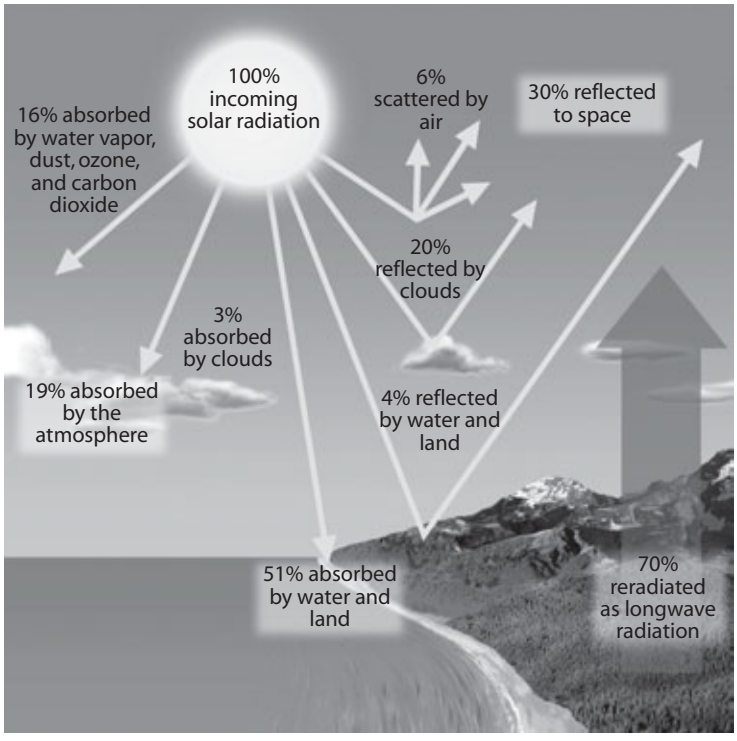
LOOKING CLOSER

5. Apply Concepts Label the parts of the photograph that represent the atmosphere, hydrosphere, geosphere, and biosphere.

What Are the Sources of Energy in the Earth System?

Energy enters the Earth system in the form of sunlight. Energy also leaves the Earth system as heat. The amount of energy that enters the Earth system is the same as the amount of energy that leaves it. In other words, the energy that enters and leaves the system is balanced. ☑

The diagram below shows what happens to the light energy that enters the Earth system. It also shows how energy is transferred, or passed, through Earth's systems.



EXTERNAL SOURCES OF ENERGY ON EARTH

For living things to carry out their life processes, energy must enter the Earth system constantly. The sun is the most important external, or outside, source of energy. Most living things ultimately get their energy from sunlight. Sunlight also heats Earth's atmosphere, land, and oceans. This heating produces winds and ocean currents that move matter through the Earth system.

Gravitational energy from the moon and sun is another external source of energy. The pull of the sun and moon on the oceans helps create tides that cause currents and help ocean water mix.

READING CHECK

6. Explain What do scientists mean when they say that the energy that enters and leaves the Earth system is balanced?

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LOOKING CLOSER

7. Calculate What percentage of solar radiation is absorbed by the atmosphere, land, and water?

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INTERNAL SOURCES OF ENERGY ON EARTH

Not all of the energy in the Earth system comes from the sun. Earth also has some sources of energy that are *internal*, or come from inside. One important internal energy source is radioactive decay. The energy from radioactive decay inside Earth warms the rock below the surface.

The heating of the rock inside Earth affects Earth's surface. When rock in the mesosphere and asthenosphere gets warmer, it rises toward the surface. Cooler rock that is near the surface sinks. The rock moves in a circular pattern, like water in a pan on a stove. This type of motion is called *convection*. Convection transfers heat from within Earth to Earth's surface. This heat affects many processes on Earth, such as volcanic eruptions. ☑

READING CHECK

8. Describe What causes convection in the asthenosphere and mesosphere?

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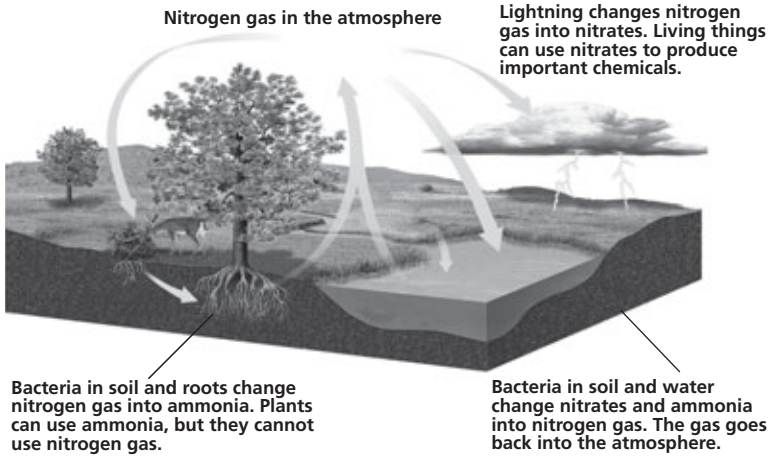
How Does Matter Move on Earth?

Like energy, matter moves between the parts of the Earth system. A place where matter or energy is stored is called a *reservoir*. For example, the oceans, atmosphere, and living things are some of the reservoirs for water. The group of processes that move matter between reservoirs is called a *cycle*. Four important matter cycles on Earth are the nitrogen cycle, the carbon cycle, the phosphorus cycle, and the water cycle.

THE NITROGEN CYCLE

Living things use nitrogen to build proteins and other important chemicals. The diagram below shows the processes that are part of the nitrogen cycle.



LOOKING CLOSER

9. Identify What kinds of living things change nitrogen gas into ammonia?

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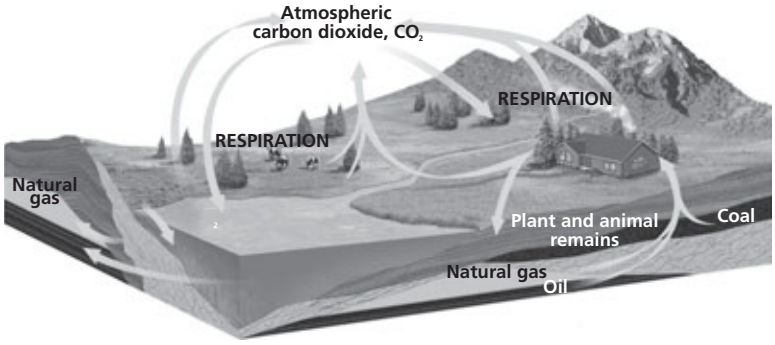
THE CARBON CYCLE

Almost all the chemicals that make up living things are based on carbon. Like nitrogen, carbon cycles through the Earth system. The diagram below shows the parts of the carbon cycle.



LOOKING CLOSER

10. Identify What are two processes that add carbon dioxide to the atmosphere?

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Scientists often break the carbon cycle into two parts: the short-term carbon cycle and the long-term carbon cycle. In one part of the short-term carbon cycle, plants take carbon dioxide from the atmosphere. They change the carbon dioxide into sugars and other chemicals in the process of *photosynthesis*. The plants use these chemicals to build and repair their cells.

Animals that eat the plants break down the chemicals in the plants. They use some of the chemicals for energy. In the process of *respiration*, they break the chemicals down to release the energy stored in them. Respiration produces carbon dioxide gas, which moves back into the atmosphere. Plants also carry out respiration, in addition to photosynthesis.

Critical Thinking

11. Describe Which two reservoirs are part of the short-term carbon cycle?

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When living things die, bacteria break down their bodies. This process is called *decomposition*. Most of the carbon in their bodies changes back into carbon dioxide gas. Respiration, photosynthesis, and decomposition make up the short-term carbon cycle.

In the long-term carbon cycle, carbon moves through all four of Earth's spheres. The remains of some living things are buried underground. Heat and pressure change them into *fossil fuels*, such as coal, oil, and natural gas. This process takes millions of years. People burn fossil fuels for energy in a process called *combustion*. Combustion produces carbon dioxide gas.

THE PHOSPHORUS CYCLE

Phosphorus is another element that living things use to build important chemicals. Unlike carbon and nitrogen, phosphorus generally does not exist as a gas. Therefore, it is not found in the atmosphere. Most of the phosphorus on Earth is stored in rocks. Water and wind can break down the rocks and release the phosphorus. It can then flow into water and soil. ☑

Plants get phosphorus from the soil. Animals get phosphorus by eating plants or other animals. The phosphorus in living things returns to the soil when the living things die and decompose.

READING CHECK

12. Identify Where is most of the phosphorus on Earth stored?

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THE WATER CYCLE

Water is always moving between the atmosphere, land, oceans, and living things. This movement of water is called the water cycle. In the water cycle, water changes state, from solid to liquid to gas and back again. The table below describes some of the processes in the water cycle.

Process	Description	Example
Evaporation	Water changes from a liquid to a gas.	Water evaporates from the oceans and moves into the atmosphere.
Condensation	Water changes from a gas to a liquid.	Water vapor in the atmosphere condenses into tiny droplets. The droplets form clouds.
Precipitation	Water falls from the atmosphere to the surface.	Water in clouds falls to the ground as rain, snow, or hail.
Transpiration	Plant leaves release water into the air.	Trees give off water through their leaves.

LOOKING CLOSER

13. Apply Concepts Which two processes in the water cycle move water from Earth's surface into the atmosphere?

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HOW PEOPLE AFFECT MATTER CYCLES

Human actions can affect Earth processes. For example, when people burn fossil fuels for energy, they affect the carbon cycle. Burning the fossil fuels makes carbon move from the geosphere into the atmosphere. This movement happens much more quickly than it would naturally.

People can also affect other matter cycles. Many people use chemicals called *fertilizers* to help their lawns and gardens grow. Fertilizers have nitrogen and phosphorus in them. Therefore, using fertilizers can change the way nitrogen and phosphorus move through the Earth system.

Name _____ Class _____ Date _____

Section 2 Review

SECTION VOCABULARY

atmosphere a mixture of gases that surrounds a planet, moon, or other celestial body	**hydrosphere** the portion of the Earth that is water
biosphere the part of Earth where life exists; includes all the living organisms on Earth	**system** a set of particles or interacting components considered to be a distinct physical entity for the purpose of study
geosphere the mostly solid, rocky part of the Earth; extends from the center of the core to the surface of the crust	

1. **Identify Relationships** Describe ways that you interact with each of Earth's four spheres every day. Give one example for each sphere.

2. **Apply Concepts** Is the human body a closed system or an open system? Use examples to support your answer.

3. **Describe** How do external sources of energy make matter move through the Earth system?

4. **Identify** Describe two ways nitrogen gas is changed into forms that living things can use.

5. **Compare** What is one way the phosphorus cycle is different from the carbon, nitrogen, and water cycles?